PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-110215

(43)Date of publication of application : 12.04.2002

(51)Int.Cl. H01M 8/24
H01M 8/02
H01M 8/12

(21)Application number : 2000-293711

(22)Date of filing : 27.09.2000

(71)Applicant : KANSAI RESEARCH INSTITUTE

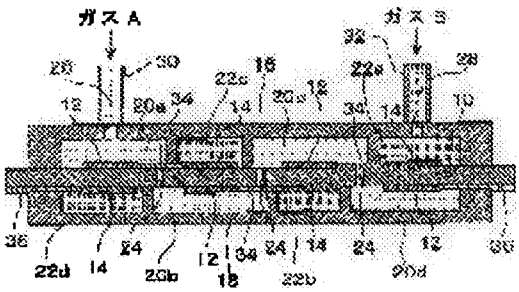
(72)Inventor : SUZUKI HAJIME
ISHIKAWA YUICHI
TOKI MOTOYUKI

(54) COMPACT FUEL CELL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a compact and light-weight fuel cell having sufficient output characteristic to enable its application even in the field of compact cells, although the fuel cell is limited to the application as large cells conventionally.

SOLUTION: A plurality of fuel cell elements constituted by forming a plurality of pairs of electrodes 12, 14 sandwiching ion conductor plates 10 therebetween are mutually connected on the same face side of the ion conduction body plates. Flow passages for two kinds of raw material gases are separated from each other and flow passages for each raw material gas are formed on both sides of the ion conduction body plate to communicate the flow passages for the same kind of raw material gas arranged on both sides of the ion conduction body plate through a communicating hole 24 provided in the ion conduction body plate.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This small fuel cell is suitably used as cells, such as a personal computer, AV equipment, home electronics, and a cellular phone, about the small fuel cell with which this invention is produced using the fuel cell, especially ion conductor board of a solid oxide type.
[0002]
[Description of the Prior Art]As for the fuel cell which transforms chemical energy into electrical energy by using oxidizing gases, such as oxygen or air, and reducing gas (fuel gas), such as hydrogen and methane, as a raw material, development has so far been furthered as the cell for electromobiles, a cell for stationary energy storage, etc. And since emission matter is water and this fuel cell serves as a source of clean energy with little environmental pollution from that the material gas needed for that power generation exists abundantly, and its power generation principle, attention is attracted in recent years and various technical proposals are made.
[0003]By the way, the fuel cell used by a technical field which was described above needs to be about hundreds of v in high tension, and needs to be about several kilowatts in high capacity. Then, in order to obtain generating high voltage, tens of unit cells are made into the stack structure which carried out the series connection in this kind of fuel cell, and for high-output capacity, right and the negative two electrodes which sandwiched the ion conductor of oxygen or hydrogen which is a component of a fuel cell, and the ion conductor -- large-area-izing -- and it is sheet-metal-ized. From these fields, examination of the high tension and high-capacity-izing of a fuel cell is performed.
[0004]
[Problem(s) to be Solved by the Invention]However, the fuel cell which is conventionally proposed as a cell of high tension and high capacity, and is developed as described above is a large-sized cell for Ryo Oshige who has stack structure and by whom the component was large-area-ized, and use of the fuel cell as a sized cell was not considered conventionally [most].
[0005]since conventionally reclaimed the use as a sized cell of portable equipments, such as a personal computer, AV equipment, home electronics, and a cellular phone, as the fuel cell restricted to the use as a large-sized cell can be applied also to the field of a sized cell, this invention was made, and it is ****. The purpose is to provide the small fuel cell which has lightweight and sufficient output characteristics.

[0006]
[Means for Solving the Problem]. In this invention, form two or more fuel cell elements in a plate of one sheet which consists a fuel cell of ion conductors in order to carry out a weight saving, small size and. It is considered as said structure and predetermined output voltage and output current were acquired a series connection or by carrying out multiple connection within one ion conductor board in those fuel cell elements.
[0007]As a method to which carry out the series connection of two or more fuel cell elements formed in one ion conductor board here, and output voltage is made to increase to a programmed voltage, A through hole is formed in an ion conductor board as drawing of longitudinal section of a small fuel cell is shown in drawing 8, How (this method is hereafter called "through hole connection type") to connect + pole formed in one field side of an ion conductor board and - pole formed in the field side of another side via a through hole can be considered.
[0008]Namely, in a through hole connection type, as shown in drawing 8, two or more + poles 62 are formed in one field side of the ion conductor board 60, the field side of another side of the ion conductor board 60 -- each + -- it is set very much to 62 to a pair, respectively -- as -- Plurality - forming 64 very much -- + -- very -- 62 and the ion conductor board 60 -- and - two or more fuel cell elements which consist of 64 very much are constituted. two or more through holes 66 are drilled by the ion conductor board 60 -- each + by the side of one field of the ion conductor board 60 -- very -- the field side of 62 and another side -- each - 64 is connected very much one by one via the through hole 66 by the lead 68, respectively. thus, + which the series connection of two or more fuel cell elements is carried out, and is located in an end, respectively -- very -- 62 -- and - the external cash-drawer leads 70 and 70 are connected very much to 64, respectively. And the blocking plate 72 is airtightly joined so that all the + poles 62 may be surrounded, and the gas chamber 76 is formed in one field side of the ion conductor board 60. In the field side of another side of the ion conductor board 60, they are all. - The blocking plate 76 is airtightly joined so that 64 may be surrounded very much, and the gas chamber 78 is formed. The gas suction holes 80 and 82 are formed, respectively, and the gas supply lines 84 and 86 are open for free passage to each gas suction holes 80 and 82, respectively, and are connected to each blocking plates 72 and 76 in them. Although a graphic display is omitted, a gas emission hole is formed, respectively, and a gas exhausting pipe is open for free passage to each gas emission hole, respectively, and is connected to each blocking plates 72 and 76 in it.
[0009]In a small fuel cell of the above composition, when it supplies to one gas chamber 74 continuously, the gas A, for example, oxygen gas, of an oxidizing quality, and supplies to the gas chamber 78 of another side continuously, the gas B, for example, hydrogen gas, of reduction nature, power generation will take place by an electrode reaction.
[0010]It is necessary to form the through hole 66 in the ion conductor board 60 which consists of an oxide which is generally a brittle material for every fuel cell elements in this through hole connection type, respectively. For this reason, a problem that a crack occurs to the ion conductor board 60, or a mechanical strength falls in a formation process of the through hole 66 will be produced. As a more important problem, when the sealing nature of the through hole 66 is insufficient, Originally two kinds of material gas (oxygen gas and hydrogen gas) which should be isolated in channel is mixed through

the through hole 66, and after a function as a fuel cell is no longer revealed and further inflammable material gas is mixed at an elevated temperature, a danger of causing ignition and explosion is.
[0011]So, in this invention, fuel cell elements were connected by the same field side of an ion conductor board, respectively without performing forming a through hole in an ion conductor board, and connecting + pole and - pole to it via that through hole. That is, as an invention concerning claim 1 has two or more fuel cell elements constituted by forming two or more electrode pairs respectively on both sides of an ion conductor board and made connection between fuel cell elements by the same field side of said ion conductor board, respectively, it constituted a small fuel cell.
[0012]In this small fuel cell, between fuel cell elements, There is also no possibility that neither generating of a crack nor a fall of a mechanical strength may take place to an ion conductor board, and two kinds of material gas may be mixed only by being connected by the same field side of an ion conductor board, respectively since many through holes for electrode connection are not formed in an ion conductor board.
[0013]In the small fuel cell according to claim 1, an invention concerning claim 2 makes it isolated mutually, and forms a channel of two kinds of material gas in both sides of said ion conductor board, respectively, each which has been arranged at both sides of an ion conductor board -- the channels of material gas of an identical kind. It was made mutually open for free passage through a communicating hole drilled by ion conductor board, and an electrode right and a negative one has been arranged corresponding to a kind of material gas which flows into both sides of an ion conductor board through inside of a channel, respectively, and acts on an electrode. [both]
[0014]In a small fuel cell of an invention concerning claim 2, while a channel of two kinds of material gas is formed in both sides of an ion conductor board, respectively, an electrode right and a negative one is arranged. [both] And the channels of material gas of an identical kind arranged at both sides of an ion conductor board are mutually open for free passage through a communicating hole of an ion conductor board, and electrodes are connected by the same field side. Therefore, there is no necessity of forming many through holes for electrode connection only by forming a communicating hole of a small number for material gas passages in an ion conductor board.
[0015]A small fuel cell of an invention concerning claim 3 is arbitrarily characterized for said two or more fuel cell elements by a series connection or carrying out multiple connection and adjusting whole output voltage and output current in the small fuel cell according to claim 1 or 2. Therefore, it becomes possible to obtain output voltage which can be set up, and a small fuel cell which has output current.
[0016]In the small fuel cell according to any one of claims 1 to 3, an invention concerning claim 4 connected two or more sheets of said ion conductor board with width and a lengthwise direction, respectively, and was taken as stack structure. By considering it as such a structure, it becomes possible to make high output voltage and capacity of a small fuel cell.
[0017]
[Embodiment of the Invention]It explains referring to drawing 1 thru/or drawing 7 for the suitable embodiment of this invention hereafter.
[0018]Drawing 1 is drawing of longitudinal section of the small fuel cell in which one example of the embodiment of this invention is shown. This small fuel cell has the ion conductor board 10 formed in tabular with the material which has ion conductivity, for example, oxygen ion conductivity, The + pole

12 of plurality [side / of the ion conductor board 10 / one / field], and plurality - 14 is formed very much, the field side of another side of the ion conductor board 10 -- each + -- very -- 12 -- and -- each - it is set very much to 14 to a pair, respectively -- as -- Plurality - forming 14 and two or more + poles very much -- + -- very -- 12 and the ion conductor board 10 -- and - two or more fuel cell elements which consist of 14 very much are constituted. With a fuel cell, although oxidizing gases, such as two kinds of material gas, i.e., oxygen, or air, and reducing gas, such as hydrogen and methane, are used, taking the case of the case where oxygen gas (gas A) and hydrogen gas (gas B) are used, it explains below.

[0019]The blocking plates 16 and 18 which have two or more crevices divided by the partition in the field of both ion conductor boards 10 are joined by airtightness, respectively. thereby -- one field side -- + of plurality [direction / inner] respectively -- the 1st oxygen gas room 20a where 12 has been arranged very much, and the 3rd oxygen gas room 20c -- and -- respectively -- an inner direction -- Plurality - the 1st hydrogen gas room 22a and the 3rd hydrogen gas room 22c where 14 has been arranged very much are formed. moreover -- the field side of another side -- + of plurality [direction / inner] respectively -- the 2nd oxygen gas room 20b where 12 has been arranged very much, and the 4th oxygen gas room 20d -- and -- respectively -- an inner direction -- Plurality - the 2nd hydrogen gas room 22b and the 4th hydrogen gas room 22d where 14 has been arranged very much are formed. Two or more communicating holes 24 are drilled by the ion conductor board 10.

[0020]And the 1st oxygen gas room 20a by the side of one field of the ion conductor board 10 and the 3rd oxygen gas room 20c, the 2nd oxygen gas room 20b by the side of the field of another side of the ion conductor board 10, and the 4th oxygen gas room 20d, It is open for free passage through each communicating hole 24, respectively, and the 3rd oxygen gas room 20c by the side of one field of the ion conductor board 10 and the 2nd oxygen gas room 20b by the side of the field of another side of the ion conductor board 10 are open for free passage through the communicating hole 24. Therefore, all the oxygen gas rooms 20a-20d are connected in channel. The 1st hydrogen gas room 22a by the side of one field of the ion conductor board 10 and the 3rd hydrogen gas room 22c, the 2nd hydrogen gas room 22b by the side of the field of another side of the ion conductor board 10, and the 4th hydrogen gas room 22d, It is open for free passage through each communicating hole (not shown), respectively, and the 3rd hydrogen gas room 22c by the side of one field of the ion conductor board 10 and the 2nd hydrogen gas room 22b by the side of the field of another side of the ion conductor board 10 are open for free passage through a communicating hole (not shown). Therefore, all the hydrogen gas rooms 22a-22d are connected in channel, and are isolated with the oxygen gas rooms 20a-20d.

[0021]It is formed in the position which it is formed in the position which the oxygen gas suction hole 26 opens for free passage in the blocking plate 16 by the side of one field at the 1st oxygen gas room 20a, and the hydrogen gas suction hole 28 opens for free passage in the 1st hydrogen gas room 22a. The oxygen gas suction hole 26 and the hydrogen gas suction hole 28 are open for free passage to the oxygen gas feed pipe 30 and the hydrogen gas feed pipe 32, respectively, and are connected to them. Although the graphic display is omitted, the gas emission hole is formed in the position which is open for free passage in the position and the 4th hydrogen gas room 22d which are open for free passage in the 4th oxygen gas room 20d, respectively, and a gas exhausting pipe is open for free passage to each gas emission hole, respectively, and is connected to the blocking plate 18 by the

side of the field of another side in it.

[0022]In each field side of the ion conductor board 10, it is with the + pole 12. - 14 is connected very much by the lead 34, respectively. thus, + which the series connection of two or more fuel cell elements is carried out, and is located in an end, respectively -- very -- 12 -- and - the external cash-drawer leads 36 and 36 are connected very much to 14, respectively.

[0023]In the small fuel cell which has the structure which was described above, the oxygen gas supplied through the oxygen gas feed pipe 30, It passes along the oxygen gas suction hole 26, and it flows into the 1st oxygen gas room 20a where the + pole 12 has been arranged, it passes along the communicating hole 24, and flows into the 2nd oxygen gas room 20b where the + pole 12 has been arranged. Thus, it is [oxygen gas] full of the inside which are each oxygen gas rooms 20a-20d where the + pole 12 has been arranged, and it flows out of the inside of the 4th oxygen gas room 20d into a gas exhausting pipe through a gas emission hole. The hydrogen gas supplied through the hydro acid matter gas supply line 32 passes along the hydrogen gas suction hole 28, flows into the 1st hydrogen gas room 22a where the - pole 14 has been arranged, passes along a communicating hole, and flows into the 2nd hydrogen gas room 22b where the - pole 14 has been arranged. Thus, it is [hydrogen gas] full of the inside which are each hydrogen gas rooms 22a-22d where the - pole 14 has been arranged, and it flows out of the inside of the 4th hydrogen gas room 22d into a gas exhausting pipe through a gas emission hole.

[0024]Drawing 2 is a top view typically shown where the passage constitution of material gas is seen from one one side side (this is called the "upper part" for convenience) of the ion conductor board 10. The solid line A is an oxygen gas channel of the ion conductor 10 upper part among a figure, and the dashed line a is a lower oxygen gas channel. The two-dot chain line B is a hydrogen gas channel of the ion conductor 10 upper part, and the dashed line b is a lower hydrogen gas channel. The communicating hole where the numerals 24 connect an upper oxygen gas channel and a lower oxygen gas channel (above) It is what was explained as a communicating hole which makes oxygen gas room 20a-20d open for free passage, and the numerals 38 are communicating holes (what was explained above as a communicating hole which makes hydrogen gas room 22a-22d open for free passage) which connect an upper hydrogen gas channel and a lower hydrogen gas channel.

[0025]As shown in drawing 2, the upper gas passageway and the lower gas passageway which were mutually connected by each communicating holes 24 and 38 are filled up with both oxygen gas (gas A) and hydrogen gas (gas B), respectively. And in section composition, the oxygen gas channel and the hydrogen gas channel are arranged so that a pair may be made with ion conductor board 10 the upper part and the bottom, as shown by the pair of the solid line A and the dashed line b, and the pair of the two-dot chain line B and the dashed line a, respectively.

[0026]Next, the developmental mechanics of the electric charge on the right and negative two electrodes in each fuel cell elements is explained that each material gas which acts on + electrode and - electrode, respectively is oxygen (O_2) gas and hydrogen (H_2) gas.

[0027]First, on - electrode, H_2 generates H^+ and e^- through the process shown with a reaction formula [$2H_2 \rightarrow 4H^+ + 4e^-$]. e^- reaches + electrode through an external circuit, and, in O_2 with which it is filled on + electrode, O^{2-} ion generates it with a reaction formula [$O_2 + 4e^- \rightarrow 2O^{2-}$] in response to

electronic supply. When the ion conductor board inserted into two electrodes is formed here, for example with oxygen ion conductors, such as full stabilization zirconia (7%Y-ZrO_2 or 7%Ca-ZrO_2), + The process which the oxygen ion which condensed on the electrode passes the inside of an ion conductor board depending on the density difference between two electrodes, and moves to - electrode occurs. And the O^{2-} ion which reached - electrode reacts to H^+ generated on - electrode with the above-mentioned reaction formula, and water is generated as shown in a reaction formula [$2O^{2-}+4H^+ \rightarrow 2H_2O$**]. The chemical reaction on two electrodes is completed by the above. It will be continued while supply of O_2 gas to + electrode and supply of H_2 gas to - electrode continue, and an electric charge will continue occurring on two electrodes, and these chemical reactions will function as a cell. And since the discharge ingredient in this chemical reaction of a series of is only water theoretically, a clean cell will be constituted.

[0028]As the method of the plane configuration of each fuel cell elements in the one ion conductor board 10, a case as a schematic diagram is shown, for example in drawing 3 can be considered. What was shown in drawing 3 is the example to which the series connection of all the fuel cell elements was carried out. In the figure, a solid line is circular, the electrode arranged at the upper surface side of the ion conductor board 10 is shown, a dashed line is circular and the electrode by the side of the upper surface and the electrode of the inverse code which makes a pair which are arranged at the undersurface side are shown. A solid line shows the inter-electrode connection arranged at the upper surface side of the ion conductor board 10, and the dashed line shows the inter-electrode connection arranged at the undersurface side. As shown in drawing 2, each gas passageway of the upper part and the bottom is filled up with oxygen gas and hydrogen gas, respectively. Therefore, corresponding to arrangement of an oxygen gas channel and a hydrogen gas channel, + electrode and - electrode will be formed in each by the side of the upper surface of the ion conductor board 10, and the undersurface, respectively. When each fuel cell elements which comprise a pair of these upper surface lateral electrodes and undersurface lateral electrodes were connected to series, respectively, and voltage of one fuel cell elements is set to v and they set current capacity to q, it means that the small fuel cell of V=16v and Q=q had comprised an example shown in drawing 3 as a whole.

[0029]The example of connection of the electrode to which current capacity was made to increase is shown in drawing 4. In this example, multiple connection of all of the five electrodes arranged in the same gas passageway (if it says by drawing 1 inside of the same gas chamber) is carried out, and the series connection of the four cell trains which comprised five electrodes, respectively is carried out. When voltage of one fuel cell elements is set to v and current capacity is set to q by such a connection configuration, it means that the small fuel cell of V=4v and Q=5q was constituted as a whole.

[0030]Although hydrogen gas was used for oxygen gas and - electrodes for + electrodes as material gas and the ion conductor board explained the small fuel cell formed by the full stabilization zirconia which is an oxygen ion conductor by the above-mentioned embodiment, This invention has a gist in the point which constitutes the small fuel cell of various output characteristics with the composition of a gas passageway, and the connection method of two or more fuel cell elements formed in an ion

conductor board, and neither the kind of material gas nor the kind in particular of ion conductor is limited. For example, it is possible to use air instead of oxygen gas, it is one side and it is possible to use reducing gas, such as methane and ethane gas, instead of hydrogen gas. When it is usable and hydrogen ion conductors, such as Nafion, use a hydrogen ion conductor as an ion conductor besides an oxygen ion conductor, It is expected to the operating temperature at the time of using ZrO_2 being about 600 ** - 700 ** that low-temperature operation of about 100 ** is attained. It is expectable to raise battery operation temperature also by thin film-ization of an ion conductor. As a hydrogen ion conductor, besides the above, perovskite type $BaCe_{0.8}Y_{0.2}O_{3-a}$, $BaCe_{0.9}Nd_{0.1}O_{3-a}$ and $SrCe_{0.95}Yb_{0.05}O_{3-a}$ and $SrZr_{0.95}Y_{0.05}O_{3-a}$ and $CaZr_{0.9}In_{0.1}O_{3-a}$ etc. can be used.

[0031]It can also be considered as the fuel cell of stack structure by connecting two or more ion conductor boards with width and a lengthwise direction, respectively.

[0032]

[Example]This invention is not limited by the contents of the following examples although the more concrete example of this invention is described below.

[0033]As an ion conductor board, the ceramic firing plate material formed in tabular [of 100 mm x 100 mmx0.2 mm^t] of Y-ZrO_2 8% was used. As shown in drawing 5, the communicating hole 42 for gas-passageway connection of 2 mmphi was formed in two or more places, and two or more Pt porous electrodes (8 mm x 8 mm) 44 were formed in both sides of the ion conductor board 40 at the ion conductor board 40, respectively. And aluminum vacuum evaporation lead pattern 46 was formed in both sides of the ion conductor board 40, respectively so that the series connection of each fuel cell elements might be carried out. In this example, 12 fuel cell elements have composition by which the series connection was carried out. Each terminal pad 48 of +-- was formed in one side of the ion conductor board 40, and the mark 50 for positioning of SUS304 board later mentioned to both sides of the ion conductor board 40, respectively was further formed in four corners.

[0034]Each gas passageway by the side of both sides of the ion conductor board 40 was formed by positioning the SUS304 boards 52 and 56 with which the crevices 54 and 58 for gas passagewaies were formed to both sides of the ion conductor board 40, respectively, and pasting up with a glass sealing agent, as shown in drawing 6 and drawing 7, respectively. In each of drawing 6 and drawing 7, a top view, a figure (b), and the figure (c) of a figure (a) are a B-B arrowed cross-section figure of a figure (a), and a C-C arrowed cross-section figure, respectively. Each suction hole 55 of oxygen gas and hydrogen gas which is material gas was formed in the SUS304 board 52, respectively, and the discharge hole 59 of emission gas was formed in the SUS304 board 56. In (a) of drawing 6, and (a) of drawing 7, dashed line-like hatching (the direction to hatching is changed according to the kind of material gas) was given to the portion used as each channel of oxygen gas and hydrogen gas for convenience.

[0035]In the small fuel cell which it has, the above structures each material gas, Pass along each suction hole 55 established in the SUS304 board 52, and it flows into each gas passageway formed with the upper and bottom each field of the ion conductor board 40, and each SUS304 boards 52 and 56, It is sent in to the innermost part, being filled up with each gas passageway by the side of the upper surface of the ion conductor board 40, and the undersurface by turns through each

breakthrough 42 of the ion conductor board 40. And the emission gas generated by the fuel cell reaction is discharged from the discharge hole provided in the SUS304 board 56.

[0036]In the small fuel cell in this example, since Y-ZrO_2 is used 8% as a formation material of the ion conductor board 40, in order to raise the oxygen ion conductivity of this material, it is necessary to carry out temperature up to the temperature of about 600 ** - 800 **. For this reason, in this example, after installing the small fuel cell into the air furnace, the power generation experiment was conducted under 600 ** temperature environment. As a result, power generation of 0.56V is possible for a small fuel cell, and the current which is about 20 mA was able to be acquired.

[0037]Although it could not say that the output characteristics of the small fuel cell concerning the above example were not necessarily enough for a practical use use, it was shown that it is possible to manufacture the small and lightweight set-type fuel cell formed on the ion conductor board (100 mm x 100 mm) of a size according to the above-mentioned example. The operating temperature of a small fuel cell by using the low-temperature operation type H^+ ion conductor of Nafion etc., The improvement is attained by attaining low-temperature operation at about 100 **, and attaining development of the charge of an ion conductor film material with higher conductivity, and thin film-ization about the output characteristics of voltage and current etc. Although it became a heavy-gage small fuel cell from having cut down and processed the SUS board for formation of a gas passageway in the above-mentioned example, if adaptation of detailed etching processing or micro-machining processing is attained even when using a metal plate, manufacture of a thinner small fuel cell will also be attained. A high increase in power by connection of the length and the horizontal mutual financing association of two or more thin fuel cells is also attained by using the feature that this small fuel cell is an aggregate of minute fuel cell elements.

[0038]

[Effect of the Invention]The small fuel cell which has output characteristics small [the invention concerning claim 1], lightweight, and sufficient can be provided, It became possible to be able to apply now the fuel cell restricted to the use as a large-sized cell also to the field of a sized cell, and to reclaim the use as a sized cell of portable equipments, such as a personal computer, AV equipment, home electronics, and a cellular phone, conventionally.

[0039]In the small fuel cell of the invention concerning claim 2, since there is no necessity of forming a through hole only by forming a small number of communicating hole in an ion conductor board, Since it does not happen that a crack does not occur to an ion conductor board, a mechanical strength does not fall, and two kinds of material gas is mixed through a through hole, either, there is no fear of the function as a fuel cell no longer being revealed, and there is also no problem of safe.

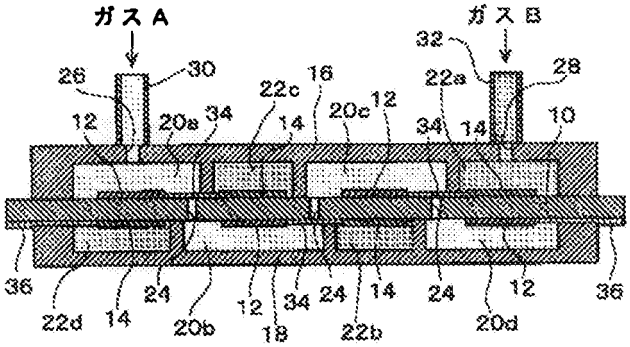
[0040]According to the invention concerning claim 3, the output voltage for which it asks, and the small fuel cell which has output current can be obtained.

[0041]According to the invention concerning claim 4, a fuel cell with high output voltage and capacity can be obtained.

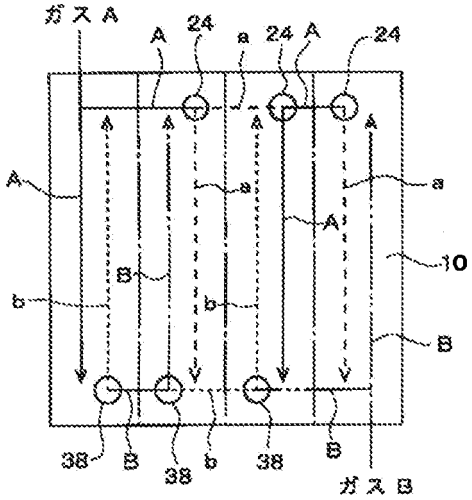
[Translation done.]

DRAWINGS

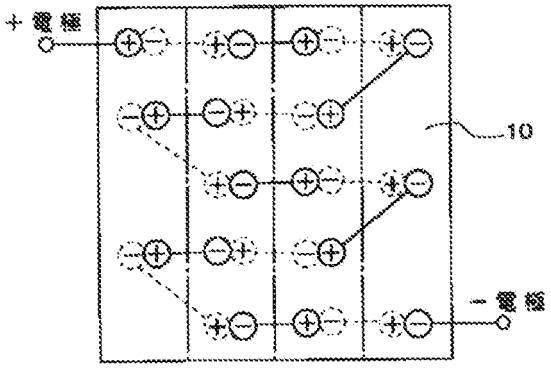
[Drawing 1]



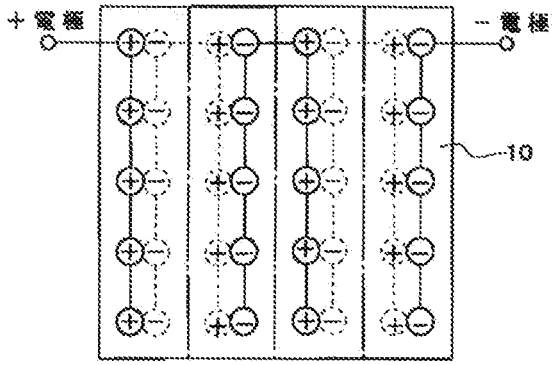
[Drawing 2]



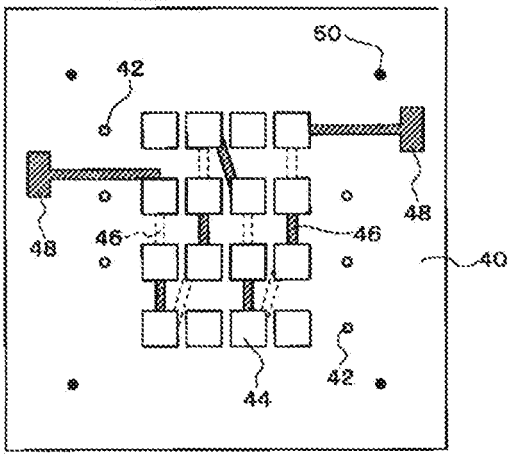
[Drawing 3]



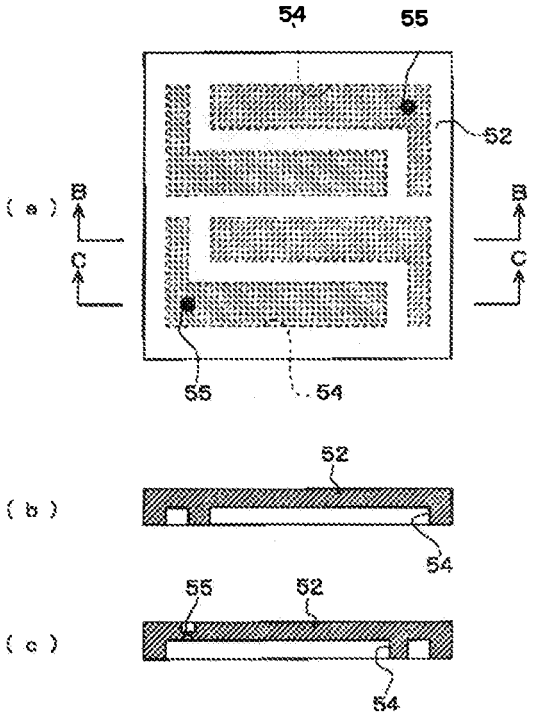
[Drawing 4]



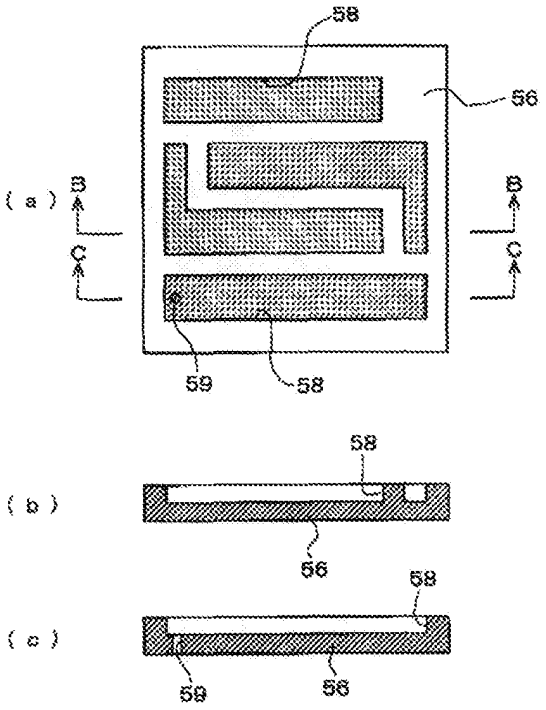
[Drawing 5]



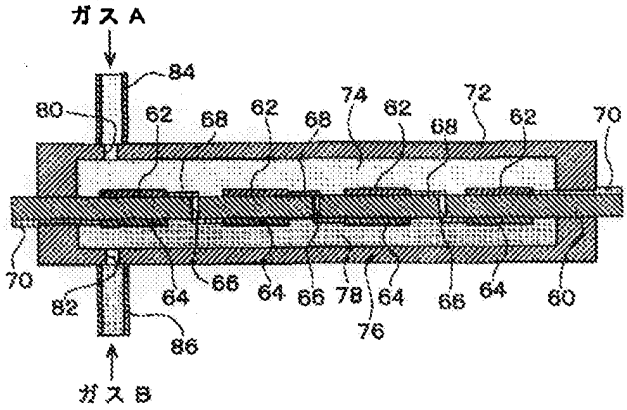
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]